AMENDMENTS TO THE SPECIFICATION:

Please replace the heading on page 1, line 5, with the following amended heading:

BACKGROUND OF THE ~~INVENTION~~ DISCLOSURE

Please replace the heading on page 1, line 14, with the following amended heading:

1. Field of the ~~Invention~~ Disclosure

Please replace the paragraph beginning on page 1, line 15, with the following amended paragraph:

The present ~~invention~~ disclosure relates to a 3-dimensional (3D) graphics, and more particularly to, a method of perceptual 3D shape description and a method and apparatus for searching a 3D graphics model database established using the description method to retrieve the similar models to a query model.

Please replace the heading on page 2, line 11, with the following amended heading:

SUMMARY OF THE ~~INVENTION~~ DISCLOSURE

Please replace the paragraph beginning on page 2, line 12, with the following amended paragraph:

The present ~~invention~~ disclosure provides an efficient method of perceptual 3-dimensional (3D) shape description that can be applied to the management of a 3D graphics model database.

Please replace the paragraph beginning on page 2, line 15, with the following amended paragraph:

The present ~~invention~~ disclosure also provides a method and apparatus for searching a 3D graphics model database that is built up using the above method to retrieve the similar models to a query model.

Please replace the paragraph beginning on page 2, line 18, with the following amended paragraph:

In one aspect of the present ~~invention~~ disclosure, there is provided a method of perceptual 3D shape description, the method including: generating nodes that respectively correspond to parts of a part-based representation of a 3D shape model, the nodes including unary attributes of the parts; generating edges that include relational attributes between the nodes; and generating an attributed relational graph of the 3D shape model that is comprised of the nodes and the edges.

Please replace the paragraph beginning on page 3, line 1, with the following amended paragraph:

In another aspect of the present ~~invention~~ disclosure, there is provided a computer readable medium having a perceptual 3D shape descriptor formed by the above method.

Please replace the paragraph beginning on page 3, line 4, with the following amended paragraph:

In another aspect of the present ~~invention~~ disclosure, there is a provided method of searching a database of 3D graphics models described by the above method, the searching method including: receiving [[a]] an input 3D graphics model; transforming the received 3D graphics model into a perceptual 3D shape descriptor; and comparing the perceptual 3D shape descriptor with each of the perceptual 3D shape descriptors of the graphics models stored in the database to retrieve the 3D graphic models that are similar to the input.

Please replace the paragraph beginning on page 4, line 16, with the following amended paragraph:

In another aspect of the present ~~invention~~ disclosure, there is provided a computer readable medium having embodied thereon a computer program for the above method of searching the perceptual 3D graphics model database.

Please replace the paragraph beginning on page 4, line 19, with the following amended paragraph:

In another aspect of the present ~~invention~~ disclosure, there is provided an apparatus for searching a database of 3D graphics models described by the description method, the apparatus including: a query input unit that receives a query that is a 3D graphics model; a model/shape descriptor transforming unit that transforms the 3D graphic model received as the query into a perceptual 3D shape descriptor; a matching unit that compares the perceptual 3D shape descriptor with each of the perceptual 3D shape descriptors of the 3D graphics models stored in the

database to retrieve the models that are similar to the perceptual 3D shape descriptor; and a model output unit that outputs the retrieved models.

Please replace the paragraph beginning on page 5, line 8, with the following amended paragraph:

The above and other features and advantages of the present ~~invention~~ disclosure will become more apparent by describing in detail exemplary embodiments thereof with reference to the attached drawings in which:

FIG. 1 exemplarily illustrates a limited shape discriminability of Shape3D;

FIG. 2 illustrates a shape deposition algorithm applied in the present ~~invention~~ disclosure;

FIG. 3 illustrates an example of generating a part-based representation for a 'cow' model;

FIG. 4 is a flowchart of a method of perceptual 3D shape description according to an embodiment of the present ~~invention~~ disclosure;

FIG. 5 illustrates edge attributes that define the relational attributes between two nodes of a perceptual 3D shape (P3DS) descriptor;

FIG. 6 is a table of binary representation form for the P3DS descriptor;

FIG. 7 is a block diagram of an apparatus for searching a database of 3D graphics models according to an embodiment of the present ~~invention~~ disclosure;

FIG. 8 is a flowchart of searching a 3D model database in the apparatus of FIG. 7 according to the present ~~invention~~ disclosure;

FIG. 9 is a flowchart of calculating the similarity between query and model graphs;

FIG. 10 illustrates vector spaces for calculating inner earth mover's distances (EMDs) and the relational attributes between nodes in the vector spaces;

FIG. 11 illustrates an example of a distance matrix constructed from the vector spaces of FIG. 10;

FIG. 12 illustrates an example of using a sketched query in a search system and the searched result;

FIG. 13 illustrates original 3D mesh object models and their P3DS descriptors expressed as attributed relational graphs (ARGs);

FIG. 14 illustrates an example of generating P3DS descriptors for differently sized 'triceratops' modes;

FIG. 15 illustrates examples of P3DS descriptors for 'triceratops' models one of which contains noise and the other is transformed; and

FIG. 16 comparatively illustrates the database search performance between the P3DS descriptor according to the present ~~invention~~ disclosure and a conventional Shape3D descriptor, which was measured by Bull's eye performance (BEP) and average normalized marching retrieval rate (ANMRR).

Please replace the heading on page 6, line 10, with the following amended heading:

DETAILED DESCRIPTION OF THE ~~INVENTION~~ DISCLOSURE

Please replace the paragraph beginning on page 6, line 11, with the following amended paragraph:

In an efficient method of 3-dimensional (3D) shape description according to the present ~~invention~~ disclosure, which can be applied to the management of a 3D

graphics model database, a 3D object is transformed into a part-based representation and then an attributed relational graph (ARG) that consists of nodes and edges. This description method is very similar to the human visual perception mechanism and thus is called a 'perceptual 3D shape descriptor'.

Please replace the paragraph beginning on page 6, line 24, and ending on page 7, line 7, with the following amended paragraph:

According to the present ~~invention~~ disclosure, a new algorithm is utilized to decompose the shape of a 3D object into parts. This decomposition algorithm involves recursively performing constrained morphological decomposition (CMD) using calculated mathematical morphology and weighted convexity. Next, it is determined whether to merge decomposed adjacent parts based on a weighted convexity difference (WCD). As such, the shape of the 3D object can be more adaptively and simply represented using the decomposition algorithm. The decomposition algorithm includes three stages as illustrated in FIG. 2. In FIG. 2, the arrows indicate the processing flow of binary images. A recursive decomposition stage (RDS) 210 follows an initial decomposition stage (IDS) 200 and is continued until QUEUE I is empty. Next, an iterative merging stage (IMS) 220 is performed on the decomposed parts that remain in QUEUE II for simpler, higher-quality representation. FIG. 3 illustrates step by step an example of part-based representation for a "cow" model. In FIG. 3, (a) and (b) are meshed and voxel representations of the cow model, respectively, (c), (d), and (e) show the results of the IDS, RDS, and IMS, respectively, and (f) is a finally generated attributed relational graph (ARG) for the cow model, in which ellipsoidal nodes and edges that connect the nodes approximate corresponding decomposed parts.

Please replace the paragraph beginning on page 7, line 8, with the following amended paragraph:

FIG. 4 is a flowchart of a method of perceptual 3D shape description according to an embodiment of the present ~~invention~~ disclosure. The method roughly includes generating nodes (step 400), generating edges (step 410), and generating an ARG (step 420). In step 400, nodes that correspond to the parts of a 3D shape model in a part-based representation, respectively, and include unary attributes of the corresponding parts are generated. In step 410, edges that define relational attributes between the nodes are generated. In step 420, an ARG that consists of the nodes and the edges is represented. In particular, the perceptual 3D shape description for a given 3D model is achieved based on the above-described part-based representation. The perceptual 3D shape descriptor is represented as an ARG that consists of node and edges. The nodes of the ARG represent the decomposed parts of the 3D model and the unary attributes of the parts, and the edges represent the relational attributes between the nodes. In an embodiment according to the present, the perceptual 3D shape descriptor utilizes four unary attributes and three relational attributes that are derived from the geometric relation between the principal axes of connected nodes.

Please replace the paragraph beginning on page 8, line 7, with the following amended paragraph:

FIG. 6 is a table of binary representation form for the perceptual 3D shape (P3DS) descriptor. In FIG. 6, volume, center, partial transform in an object-oriented coordinate system, variance on each principal axis, and convexity form unary node

attributes. The variance implies the degree of distribution of voxels that form an ellipsoid on each 3D principal axis. In this embodiment, the maximum number of nodes (Nnodes) that the P3DS descriptor can have was set to 32. In order to reduce the capacity of a memory to store the P3DS descriptor, each of the unary attributes was quantized into a predetermined number of bits, preferably 8 bits. With the assumption that all attributes are quantized into 8 bits as in the example of FIG. 6 and the P3DS descriptor has 5 nodes, the P3DS descriptor has a size of only 72 bytes. Alternatively, different numbers of quantization bits may be assigned to attributes. The data of a 3D shape described by the perceptual 3D shape description method according to the present ~~invention~~ disclosure may be recorded in a computer readable medium.

Please replace the paragraph beginning on page 8, line 21, with the following amended paragraph:

A method and apparatus for searching a 3D graphics model database according to the present ~~invention~~ disclosure will now be described. The 3D graphics model database stores 3D graphics models described using the above P3DS descriptor.

Please replace the paragraph beginning on page 8, line 24, with the following amended paragraph:

FIG. 7 is a block diagram of an apparatus for searching a database of 3D graphics models according to an embodiment of the present ~~invention~~ disclosure. The apparatus of FIG. 7 includes a query input unit 700, a model/shape descriptor transforming unit 710, a matching unit 720, and a model output unit 730.

Please replace the paragraph beginning on page 9, line 10, with the following amended paragraph:

A method of searching a 3D model database in the above apparatus will now be described. FIG. 8 is a flowchart of searching a 3D model database in the above apparatus according to the present ~~invention~~ disclosure.

Please replace the paragraph beginning on page 9, line 24, with the following amended paragraph:

Step 850 of searching the database for the similar models includes receiving a pair of graphs (step 900), defining the volumes of the nodes as weights (step 910), comparing the transformed P3DS descriptor with each of the perceptual graphics models using the double EMD method (step 920), and finding the models that are similar to the transformed P3DS descriptor (step [[930]] 950).

Please replace the paragraph beginning on page 12, line 15, with the following amended paragraph:

Functions of the P3DS descriptor used in the present ~~invention~~ disclosure to retrieve the similar 3D models from a database are superior to conventional methods. The most significant feature of the P3DS descriptor used in the present ~~invention~~ disclosure lies in that it perfectly matches the human shape cognition mechanism. Accordingly, it is possible to describe the topological shapes of 3D models using the P3DS descriptor according to the present ~~invention~~ disclosure and obtain proper search results. For example, if the P3DS descriptor contains information on an object that is comprised of 6 parts, for example, including a part for

head, four parts for legs, and a part for tail, the object described by the P3DS descriptor may be recognized as having an animal shape and animal shapes may be retrieved from a database.

Please replace the paragraph beginning on page 13, line 7, with the following amended paragraph:

The results of a simulation test performed on the perceptual 3D shape descriptor according to the present ~~inventions~~ disclosure are as follows. In the simulation test, P3DS descriptors were generated. FIG. 13 shows original 3D mesh object models and their P3DS descriptors expressed in ARG forms. As is apparent from FIG. 13, there are perceptual coherences between the mesh models and P3DS descriptors. In other words, a man or a helicopter can be accurately perceived from their P3DS descriptors. In FIG. 14, (a) and (b) are enlarged and reduced versions of the 3D object (f) in FIG. 13, respectively. However, they are expressed as the same P3DS descriptor shown in (c) of FIG. 14, independent of their sizes. FIG. 15 shows examples of P3DS descriptors when an object includes a noise component and is transformed. The object in (a) of FIG. 15 has a noise-containing vertex compared to the original 3D object in (f) of FIG. 13, the object in (b) of FIG. 15 has a longer horn than the original 3D object, and the object in (c) of FIG. 15 has longer legs than the original 3D object. As can be observed from (d), (e), and (f) of FIG. 15, the generated P3DS descriptors reflect the transformations from the original object well such a degree that the original object can be analogized from the P3DS descriptors. The above results of the simulation test indicate that the P3DS descriptor according to the present ~~invention~~ disclosure can accurately describe the shape of a 3D object independent of size variation, noise, and transformation and is

perceptually coherent with the original object. In addition, the ARG representation of the P3DS descriptor can be utilized to search a 3D model database and provide searched results that coincide with the human visual perception mechanism.

Please replace the paragraph beginning on page 13, line 19, with the following amended paragraph:

A method of searching a P3DS model database according to the present ~~invention~~ disclosure will now be described. In order to evaluate the database search performance of the P3DS descriptor, a database search test was conducted using a database that is currently used by MEPG-7. The database used included 3,903 3D graphics models categorized in a 4-hierarchical structure that includes 8 top categories and 102 leaf categories. Bull's eye performance (BEP) and average normalized marching retrieval rate (ANMRR) used by MPEG-7 were applied as performance evaluation measures. A leaf category which a query model belongs to was used as a true value. A higher BEP score and a lower ANMPP score mean a more effective performance.

Please replace the paragraph beginning on page 14, line 5, with the following amended paragraph:

FIG. 16 comparatively shows the search performance between the P3DS descriptor according to the present ~~invention~~ disclosure and a conventional Shape3D descriptor for a set of 366 query models. The query models used belong to 10 selected leaf categories. As is apparent from FIG. 16, the performance of the P3DS descriptor according to the present ~~invention~~ disclosure as measured by BEP and ANMRR are excellent absolutely and over the conventional Shape3D descriptor.

Please replace the paragraph beginning on page 14, line 11, with the following amended paragraph:

As described above, a method of P3DS description according to the present ~~invention~~ disclosure enables a user to use a query by sketch or editing over conventional methods. This advantage of the present ~~invention~~ disclosure is very important in connection with contents-based database searching.

Please replace the paragraph beginning on page 14, line 15, with the following amended paragraph:

In addition, according to the present ~~invention~~ disclosure, a double EMD technique is applied to the matching of query and model representations so that a model graph similar to a query graph can be retrieved more accurately from a database.

Please replace the paragraph beginning on page 14, line 18, with the following amended paragraph:

Furthermore, according to the present ~~invention~~ disclosure, both geometric information and topological information are utilized, and the performance of the search system can be improved through many-to-many mapping of nodes between query and model graphs.

Please replace the paragraph beginning on page 14, line 22, with the following amended paragraph:

The ~~invention~~ disclosure may be embodied in a general purpose digital computer by running a program from a computer readable medium, including but not limited to storage media such as magnetic storage media (e.g., ROM's, floppy disks, hard disks, etc.), optically readable media (e.g., CD-ROMs, DVDs, etc.) and carrier waves (e.g., transmissions over the Internet).